

A detailed illustration of an astronaut in a white spacesuit working on a large, metallic spacecraft module in the vacuum of space. The astronaut is positioned on the right side of the frame, leaning over a large, cylindrical component of the module. The module has a complex structure with various panels, pipes, and a small American flag. In the background, two large, gold-colored solar panel arrays are visible, extending from the module. A bright sun is shining in the upper left corner, creating a strong light source and casting shadows. The overall scene is set against a dark, starry background.

Asteroid Redirect Mission and The Future of Human Spaceflight

Asteroid Initiative Idea Synthesis Workshop
November 20-22, 2013

Join the discussion and send questions to: **#NASAasteroid**

Principles for Incrementally Building Capabilities



Six key strategic principles to provide a sustainable program:

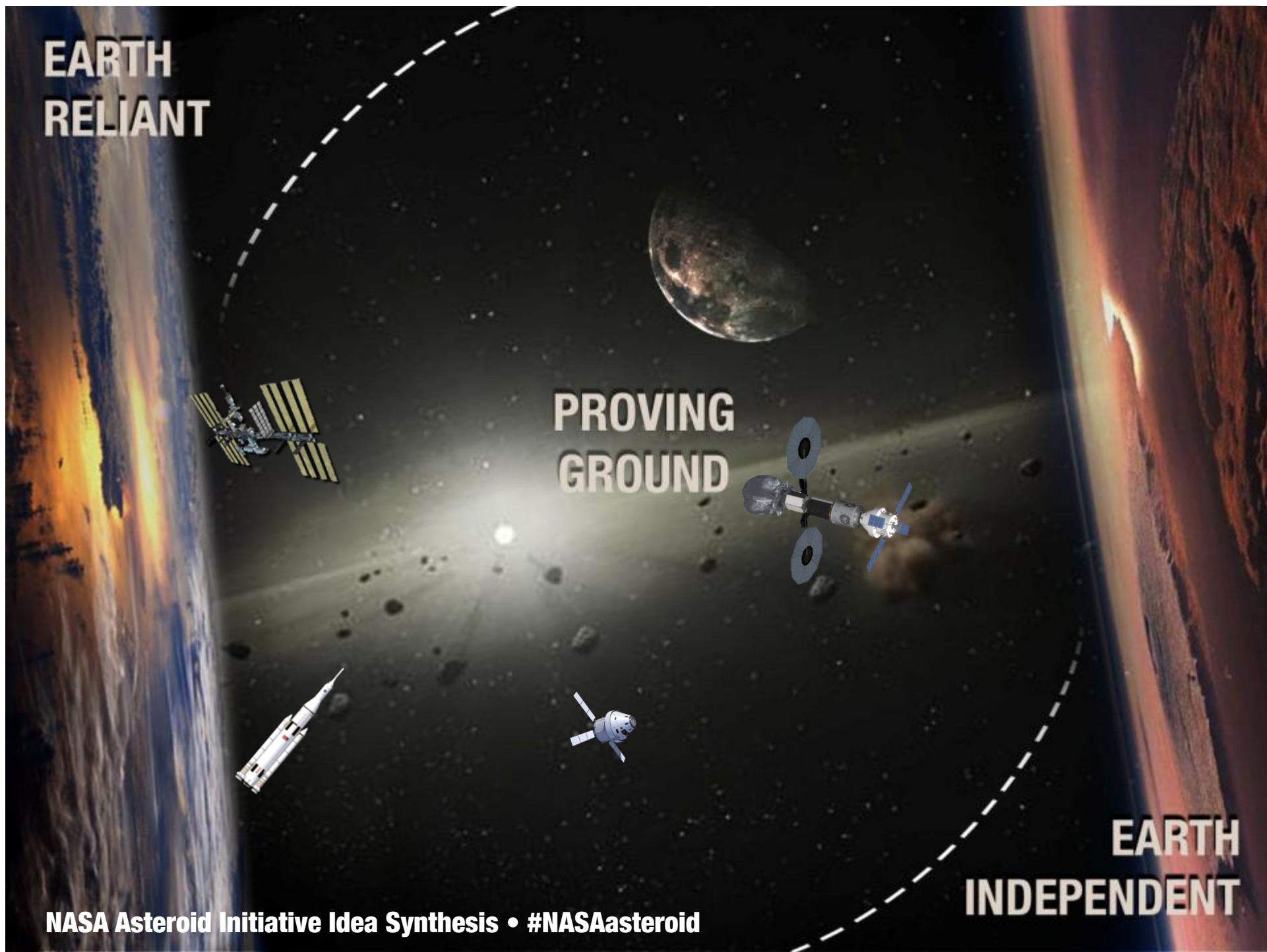
1. Executable with current *budget with modest increases*
2. Application of *high Technology Readiness Level (TRL)* technologies for near term, while focusing research on technologies to address challenges of future missions
3. *Near-term mission* opportunities with a defined cadence of compelling missions providing for an incremental buildup of capabilities for more complex missions over time
4. Opportunities for *US Commercial Business* to further enhance the experience and business base learned from the ISS logistics and crew market
5. *Multi-use* Space Infrastructure
6. Significant *International and commercial participation*, leveraging current International Space Station partnerships and commercial companies

**EARTH
RELIANT**

**PROVING
GROUND**

**EARTH
INDEPENDENT**

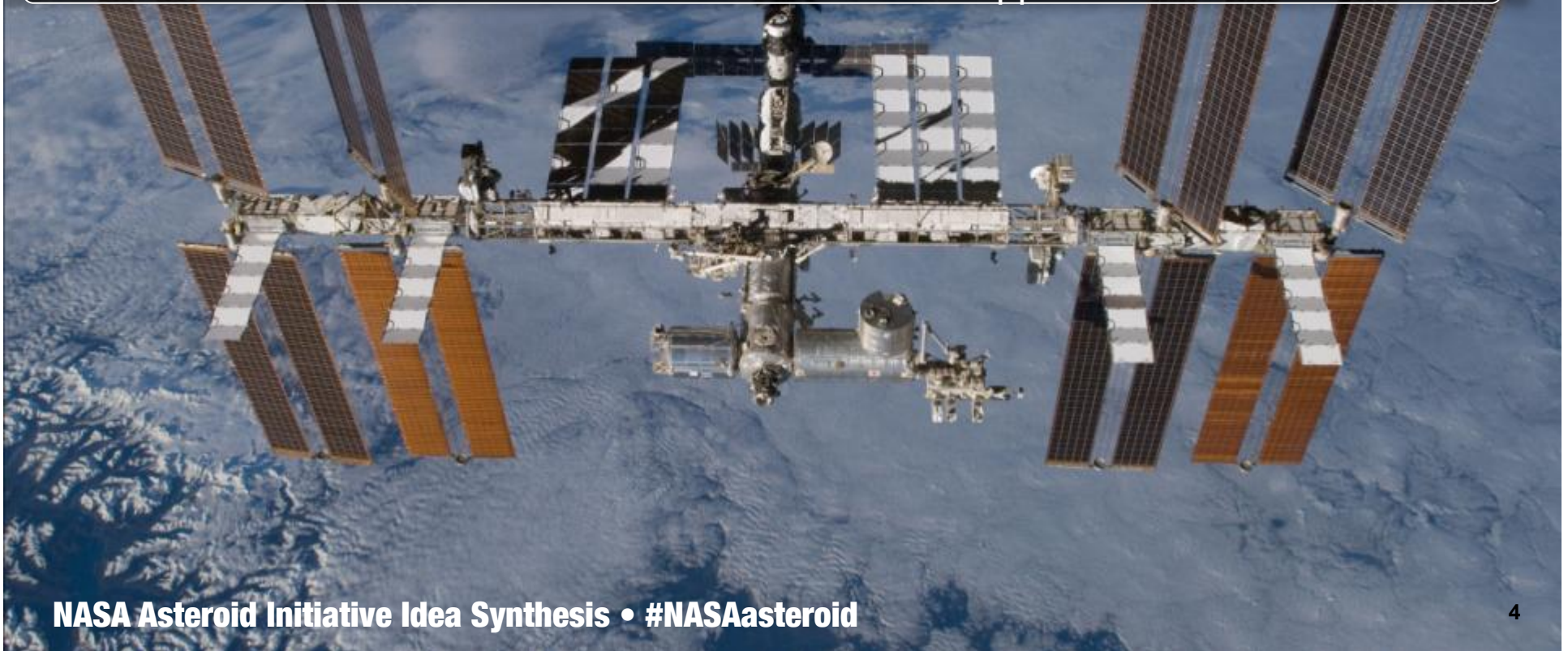
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ISS Enables Long Duration Exploration



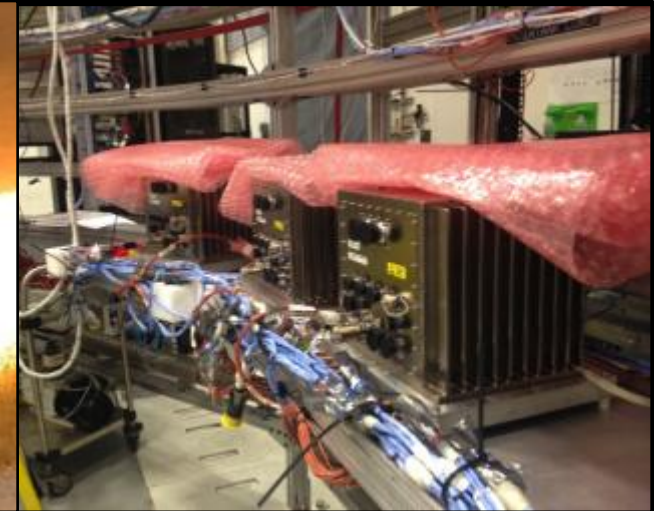
- Health and Human Performance
- Crew Habitability and Logistics
- System and Technology Testbed
 - Docking
 - High Reliability Closed Loop Life Support
 - Long Term System Performance
 - Logistics and Maintenance Reduction
- Commercial Cargo and Crew Transportation Services to LEO
- Commercial Application of Microgravity and Space Research for Terrestrial Application



Three Successful Ground Tests of Booster Developmental Motors



Core Stage Flight Computers Installed



Space Launch System is a versatile rocket capable of transporting humans, habitats, and support systems directly to deep space.



Barrel Section Complete at MAF



RS-25 Test Firing



Barrel Weld Center

Orion Propulsion and Life Support
System Assembly



Parachute Drop Tests



Orion Post Landing Recovery Test



Orion is the first spacecraft in history capable of taking humans to multiple destinations in deep space.



Heat Shield Developmental Flight
Instrumentation Complete



Thermal Protection System and
Backshell



Successful Fairing Separation Test

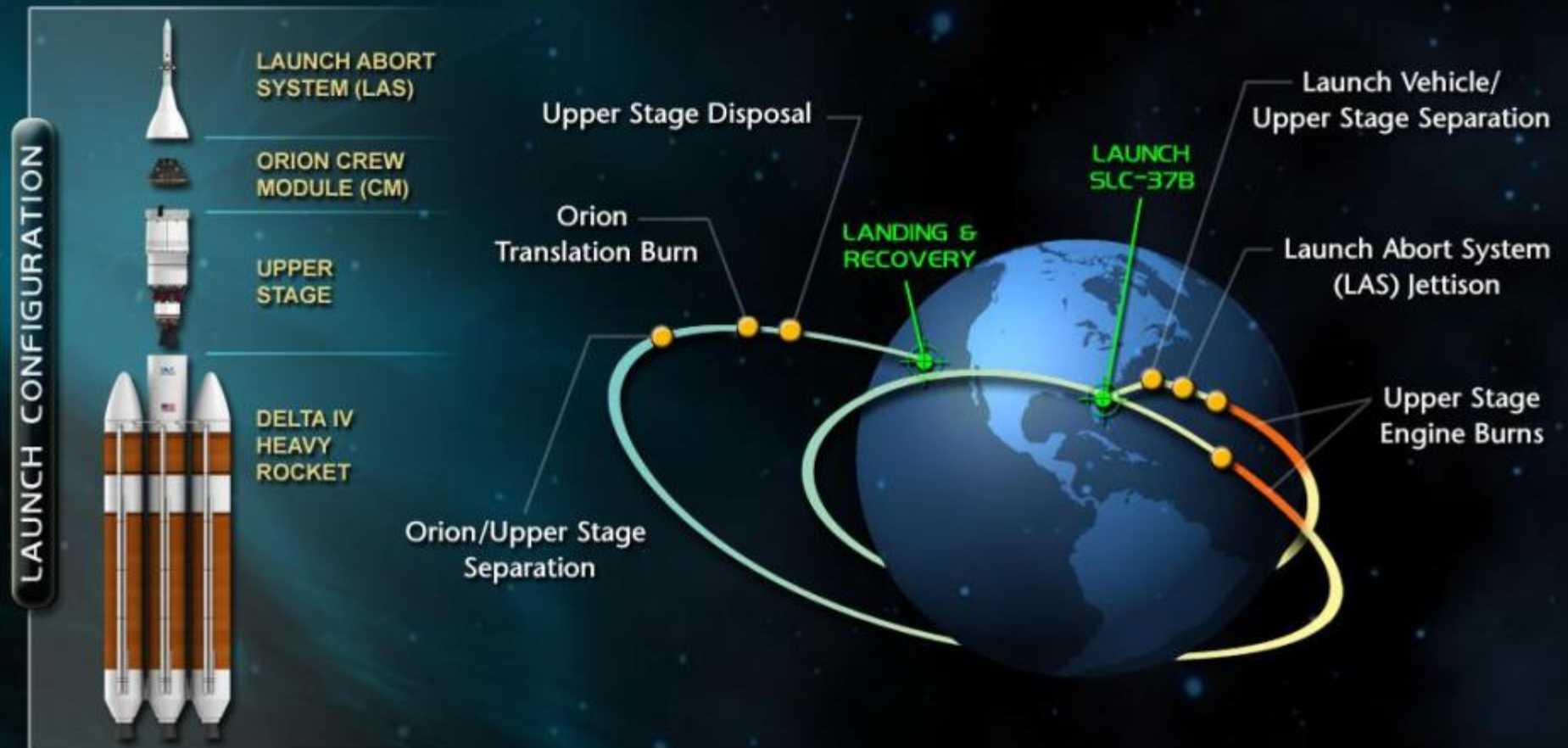
2014 Exploration Flight Test One (EFT-1)



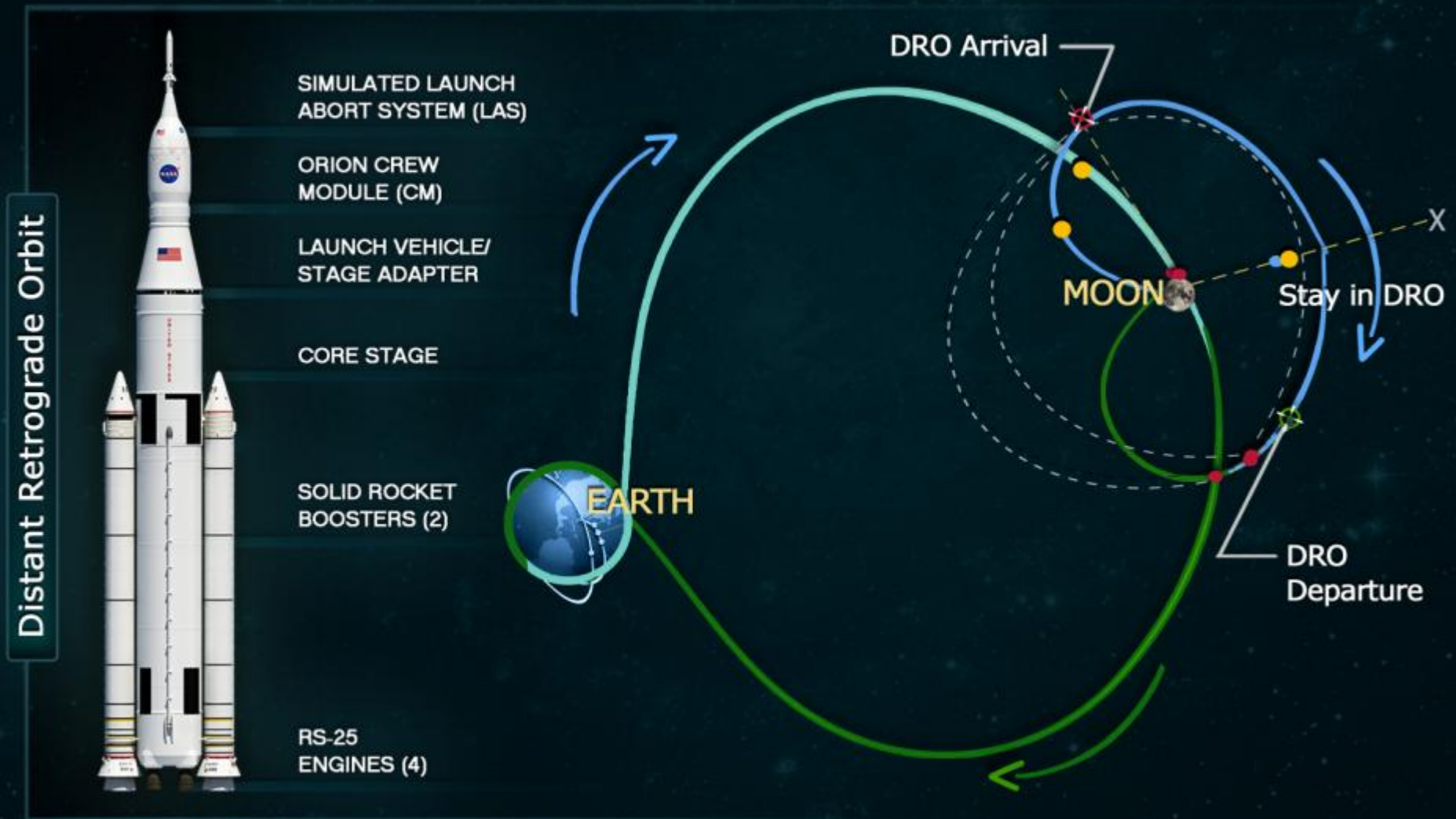
EXPLORATION FLIGHT TEST ONE

OVERVIEW

TWO ORBITS • 20,000 MPH ENTRY • 3,671 MILE APOGEE • 28.6 DEGREE INCLINATION



Exploration Mission One (EM-1)



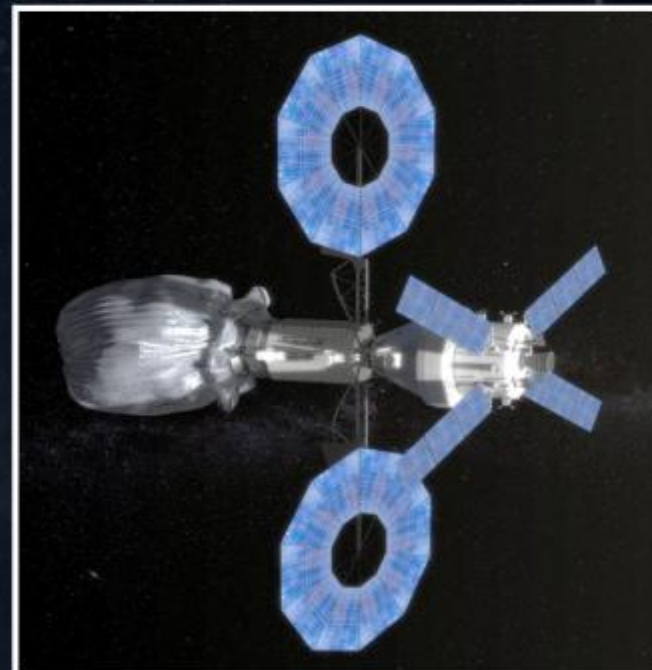
Asteroid Redirect Crewed Mission Overview



Deliver crew
on SLS/Orion



Attached Orion to robotic spacecraft



Perform extra-vehicular activity (EVA) to retrieve asteroid samples



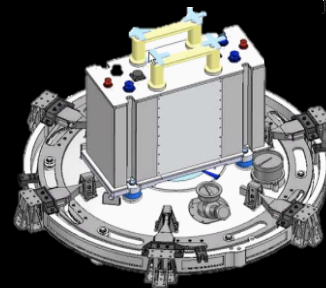
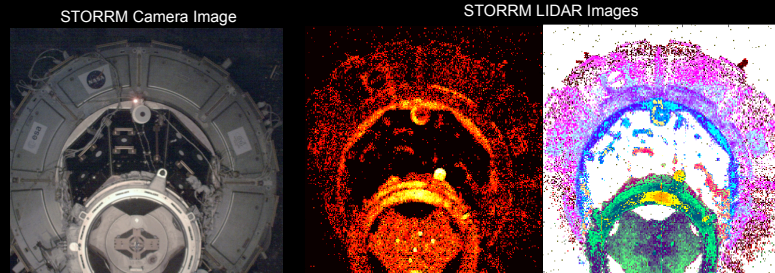
Return crew safely to Earth with
asteroid samples in Orion

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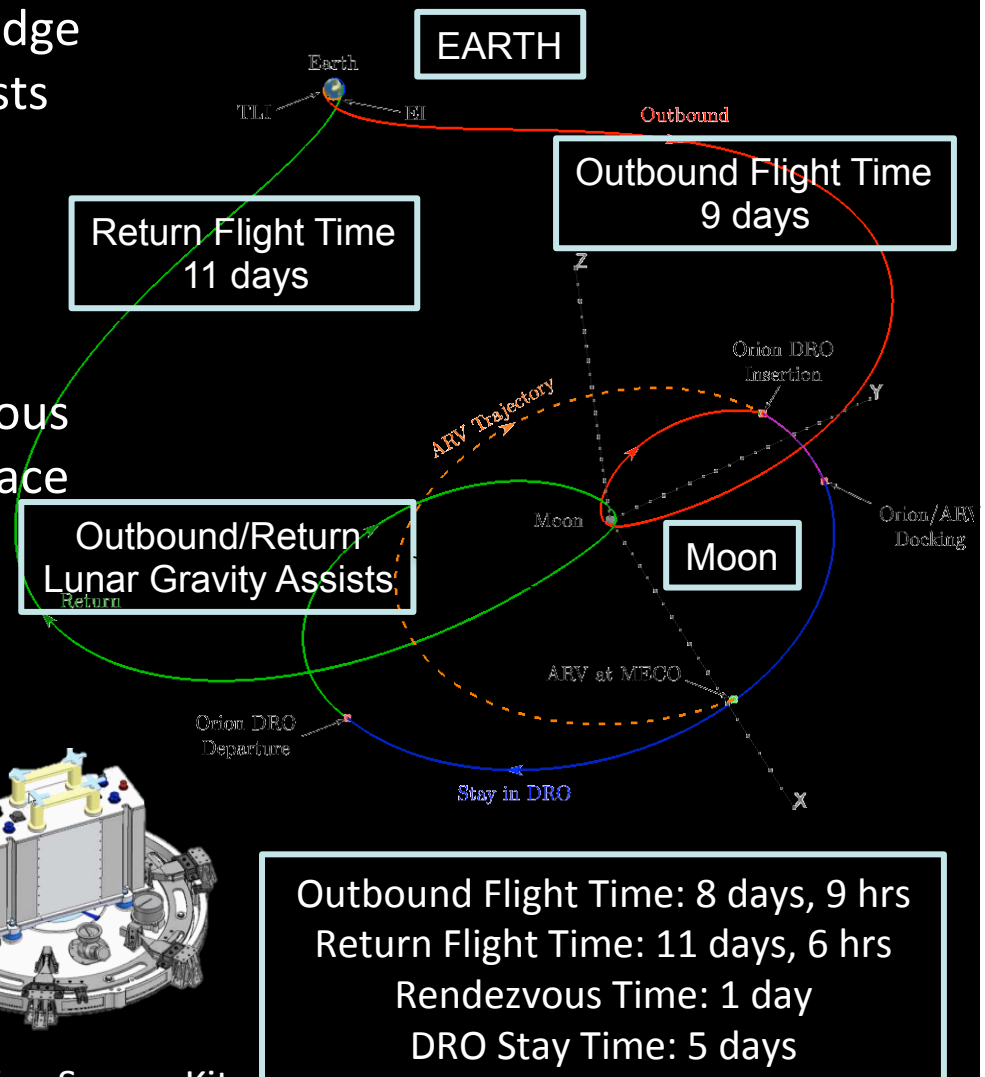
ARM Trajectory and Rendezvous



- Common sensors derived from knowledge gained from Space Shuttle Detailed Tests
- Synergy between crewed and robotic mission sensors
- Trajectory launch constraints, rendezvous techniques, navigation enable deep space



Notional Relative Navigation Sensor Kit

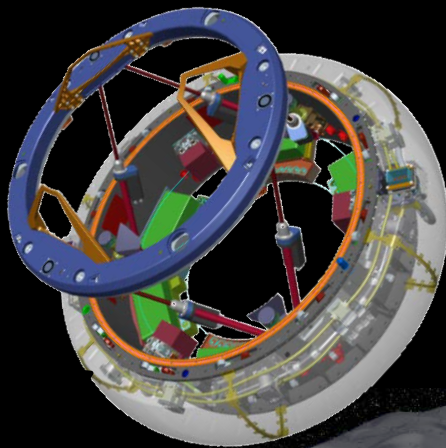


Docking System

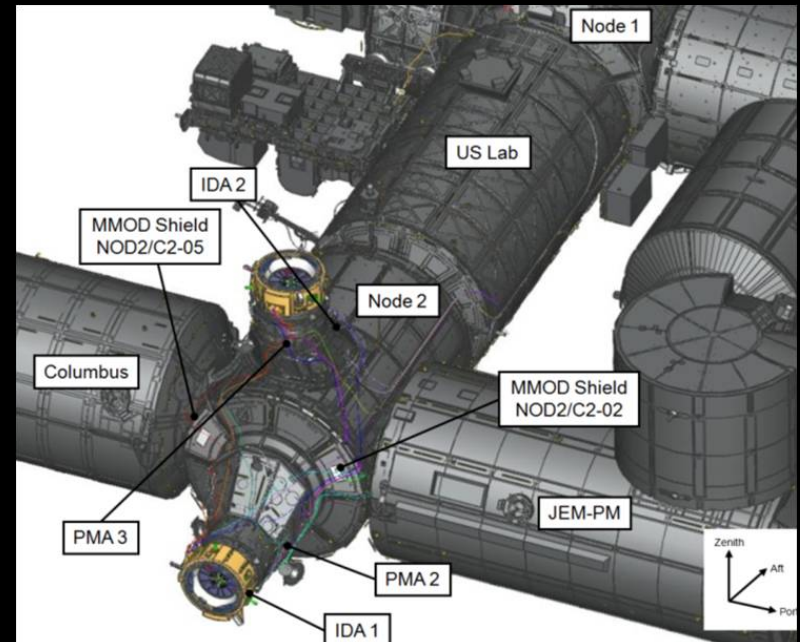
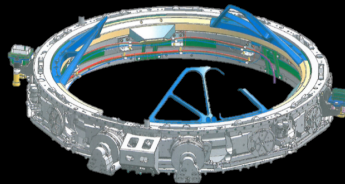


- **Docking System for Orion and Robotic Spacecraft leverages development of International Docking System Standard**

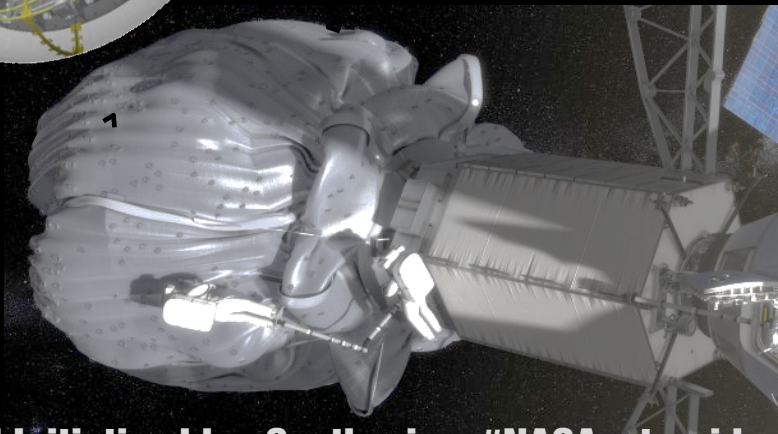
Orion Active
Docking Mechanism
(extended)



Robotic Spacecraft
Passive Docking
Mechanism



- International Docking Adapter will create a docking port on ISS
- Compatible with new International Standard
- Provides Power and data utility connections to visiting vehicles
- Delivered to ISS in trunk of Space-X Dragon Cargo Vehicle



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EVA Technique Development



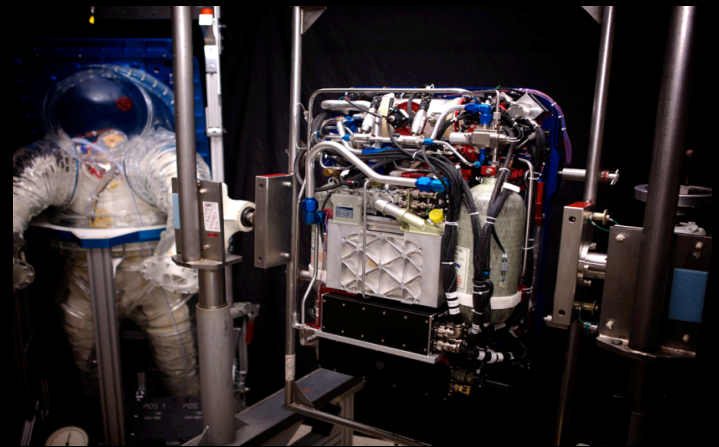
Watch the video at:

<http://youtu.be/10wmZYrTsGY>

EVA Suit and Primary Life Support System (PLSS)



- Exploration PLSS technology being developed as multi-suit compatible life support system
 - Initial prototype completed in FY13
 - Integrated metabolic and functional testing to be completed this fiscal year
- Analyzing interface design for Asteroid Redirect Mission
- Additions to Modified Advanced Crew Escape Suit (MACES) that allow for extended EVA



MACES with PLSS
and EVA Suit Kit

Completed PLSS Test Article



Helmet Cameras & Lights

PLSS Backpack & Suit
Adaptors

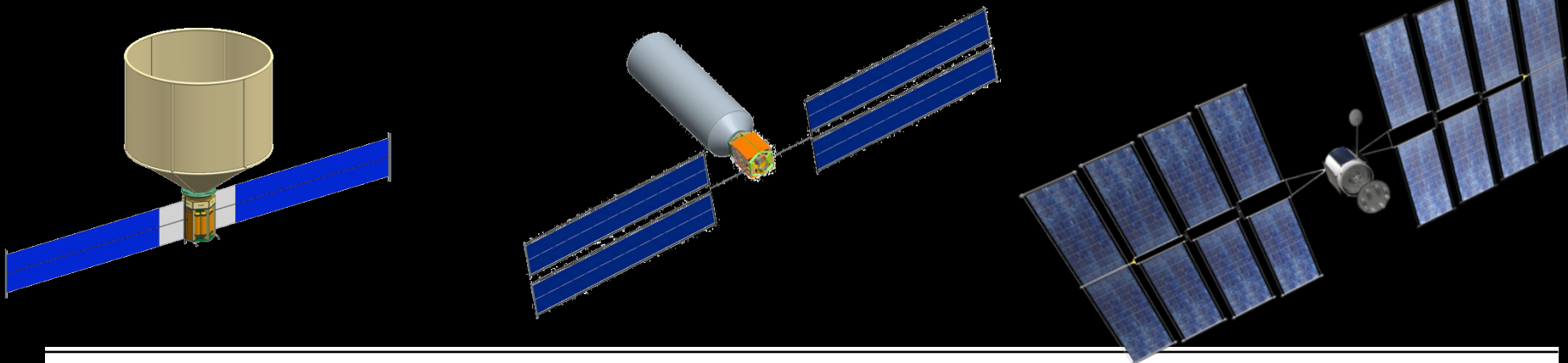
Display & Control
Module

EMU Heated Gloves

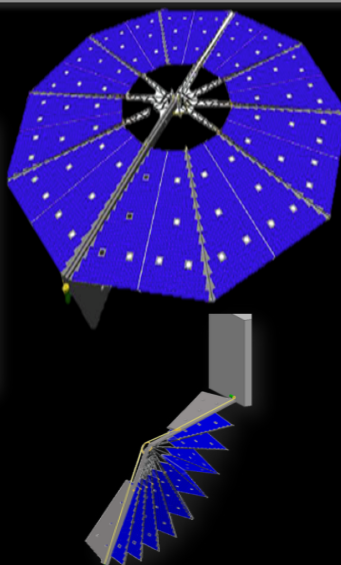
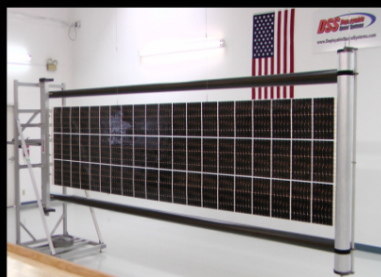
Tether & Tool Harness

Thermal Micro-meteoroid
Garment

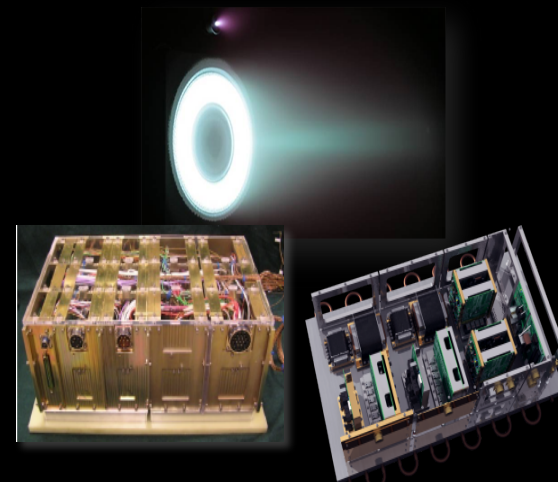
High Powered Solar Electric Propulsion Enables Exploration



Power	40-50 kW	90-100 kW	250+ kW
Thrusters	3 @ 13.3kW ea	7 @ 13.3kW ea	7 @ 35kW ea



Solar Arrays



Thruster and Power Processing Unit

ARM Provides First Steps to Mars/Other Destinations



	Mission Sequence	Current ISS Mission	Asteroid Redirect Mission	Long Stay In Deep Space	Mars Orbit	Mars Surface, Short Stay	Mars Surface, Long Stay
Mars Destination Capabilities	In Situ Resource Utilization & Surface Power						X
	Surface Habitat						X
	Entry Descent Landing, Human Lander					X	X
	Advanced Cryogenic Upper Stage				X	X	X
Initial Exploration Capabilities	Solar Electric Propulsion for Cargo		X	X	X	X	X
	Exploration EVA		X	X	X	X	X
	Crew Operations beyond LEO (Orion)		X	X	X	X	X
	Deep Space Guidance Navigation and Control/Automated Rendezvous		X	X	X	X	X
	Crew Return from Beyond LEO – High Speed Entry (Orion)		X	X	X	X	X
	Heavy Lift Beyond LEO (SLS)		X	X	X	X	X
ISS Derived Capabilities	Deep Space Habitat	* →		X	X	X	X
	High Reliability Life Support	* →		X	X	X	X
	Autonomous Assembly	* →		X	X	X	X

Asteroid Redirect Enables Future Exploration Missions



The Asteroid Redirect Mission is a critical first step to reducing risk and advancing core capabilities and mission operations required for human exploration of Mars.

- System Capabilities
 - Orion crew vehicle and SLS launch vehicle performance
 - Solar electric propulsion for pre-deployment of logistics
 - Potential addition of Exploration Augmentation Module
 - Provide long duration system testing
 - Deep space environmental testing
 - Integration of vehicle systems
 - Rendezvous and Docking
- Deep Space Operational Capabilities
 - Autonomous operations to mitigate moderate communication time delays
 - Deep space navigation
 - Potential high band-width deep space communications (follow on to lunar communication)
 - Surface system interactions and mobility with near zero-g solar system objects (EVA suit and tools, surface ops)
 - Sample collection and curation (science, analog to Mars planetary protection operations)

